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Hidaka et al.

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(54) **FRAME TRANSFER METHOD AND NODE IN ETHERNET**

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(73) Assignee: **NEC Corporation**, Tokyo (JP)

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(30) **Foreign Application Priority Data**

Aug. 22, 2002 (JP) 2002-242529

(51) **Int. Cl.**
G06F 15/16 (2006.01)
H04L 12/28 (2006.01)
H04L 12/56 (2006.01)

(52) **U.S. Cl.** **709/206**; 709/230; 370/389; 370/392

(58) **Field of Classification Search** 709/206, 709/230

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,400,331	A *	3/1995	Lucak et al.	370/401
6,058,419	A *	5/2000	Taniguchi	709/223
6,181,699	B1	1/2001	Crinion et al.	370/392
6,339,595	B1	1/2002	Rekhter et al.	
6,526,056	B1 *	2/2003	Rekhter et al.	370/392
6,760,776	B1 *	7/2004	Gallo et al.	709/238
6,788,681	B1 *	9/2004	Hurren et al.	370/389
7,072,346	B2 *	7/2006	Hama	370/395.53
2003/0037163	A1 *	2/2003	Kitada et al.	709/236
2004/0066780	A1 *	4/2004	Shankar et al.	370/389
2004/0066781	A1 *	4/2004	Shankar et al.	370/389
2004/0151120	A1 *	8/2004	Shankar et al.	370/249

FOREIGN PATENT DOCUMENTS

JP	2001-320420	11/2001
JP	2002-164937	6/2002

OTHER PUBLICATIONS

Chinese Office Action dated Nov. 14, 2008 (with partial English translation).

* cited by examiner

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(57) **ABSTRACT**

A node to relay the Ethernet frame provided with means to insert, in the relay process of the frame, two or more VLAN tags into the frame at a time and to remove the inserted VLAN tags wherein a TTL area to show the frame survival time is provided in the VLAN tag to be inserted to the frame so that whether the survival time has been elapsed or not is checked by the value in the TTL area and the frame after elapse of the survival time is discarded without being relayed.

18 Claims, 18 Drawing Sheets

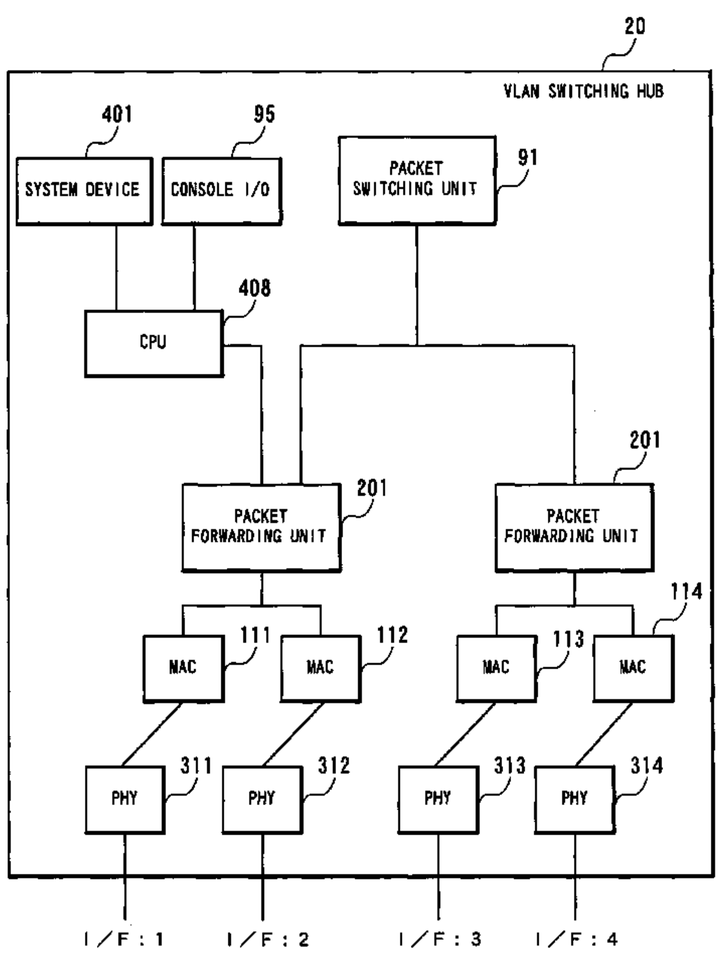


FIG. 1

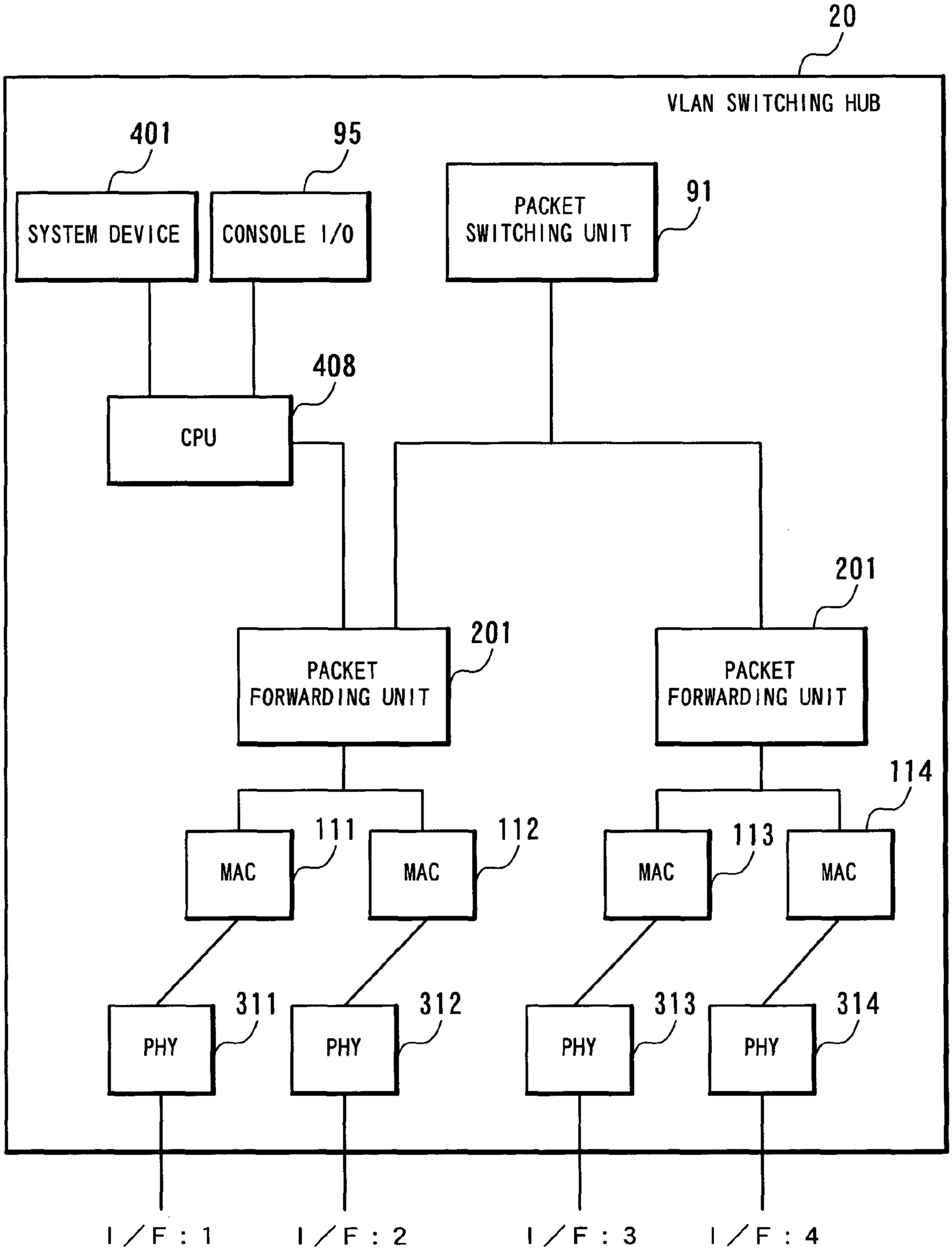

20
VLAN SWITCHING HUB
401
95
SYSTEM DEVICE
CONSOLE I/O
PACKET SWITCHING UNIT
91
408
CPU
201
201
PACKET FORWARDING UNIT
PACKET FORWARDING UNIT
114
111
112
113
MAC
MAC
MAC
MAC
311
312
313
314
PHY
PHY
PHY
PHY
I/F : 1
I/F : 2
I/F : 3
I/F : 4

FIG. 2

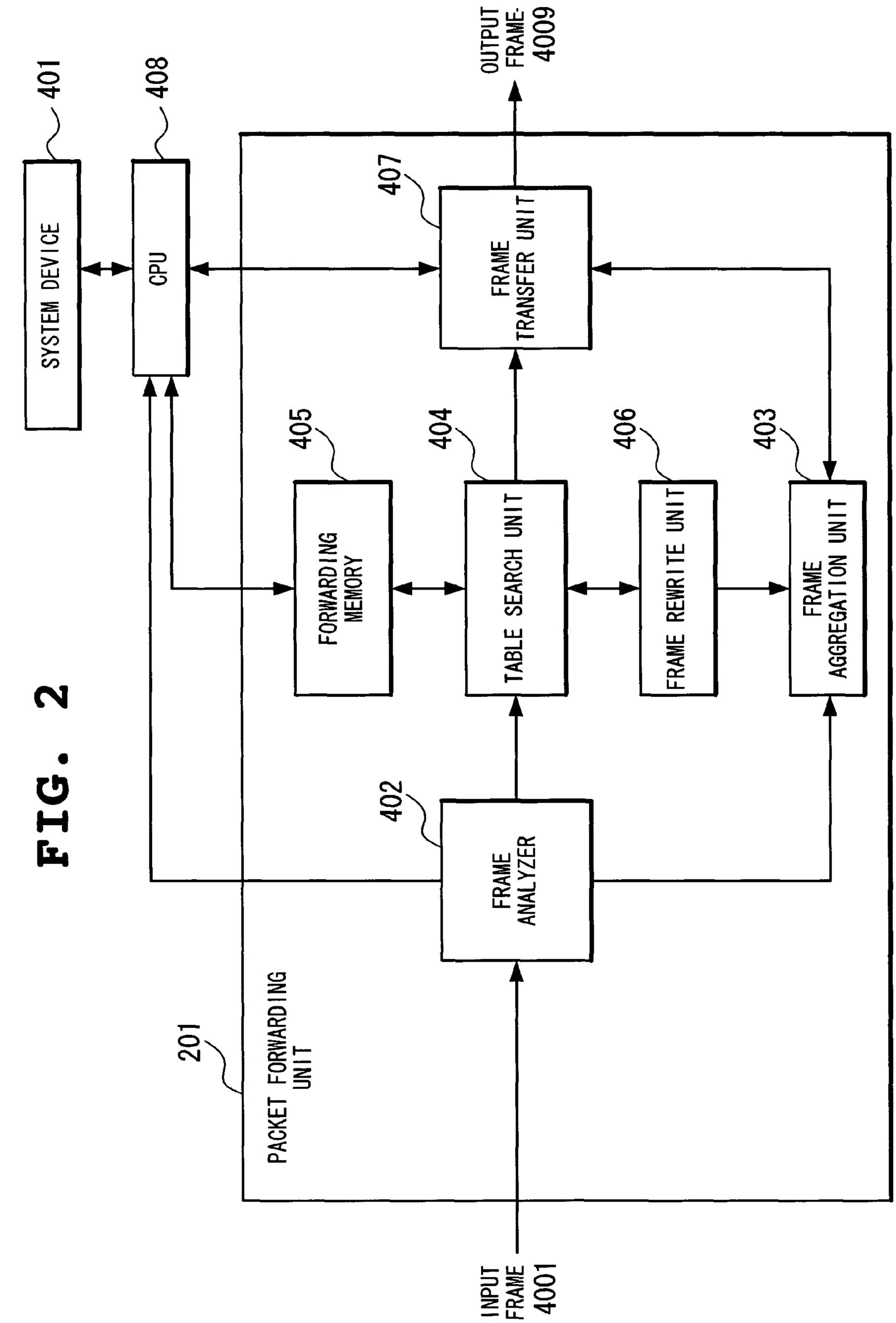

201
PACKET FORWARDING UNIT
401
SYSTEM DEVICE
408
CPU
407
FRAME TRANSFER UNIT
405
FORWARDING MEMORY
404
TABLE SEARCH UNIT
406
FRAME REWRITE UNIT
403
FRAME AGGREGATION UNIT
402
FRAME ANALYZER
OUTPUT FRAME 4009
INPUT FRAME 4001

FIG. 3

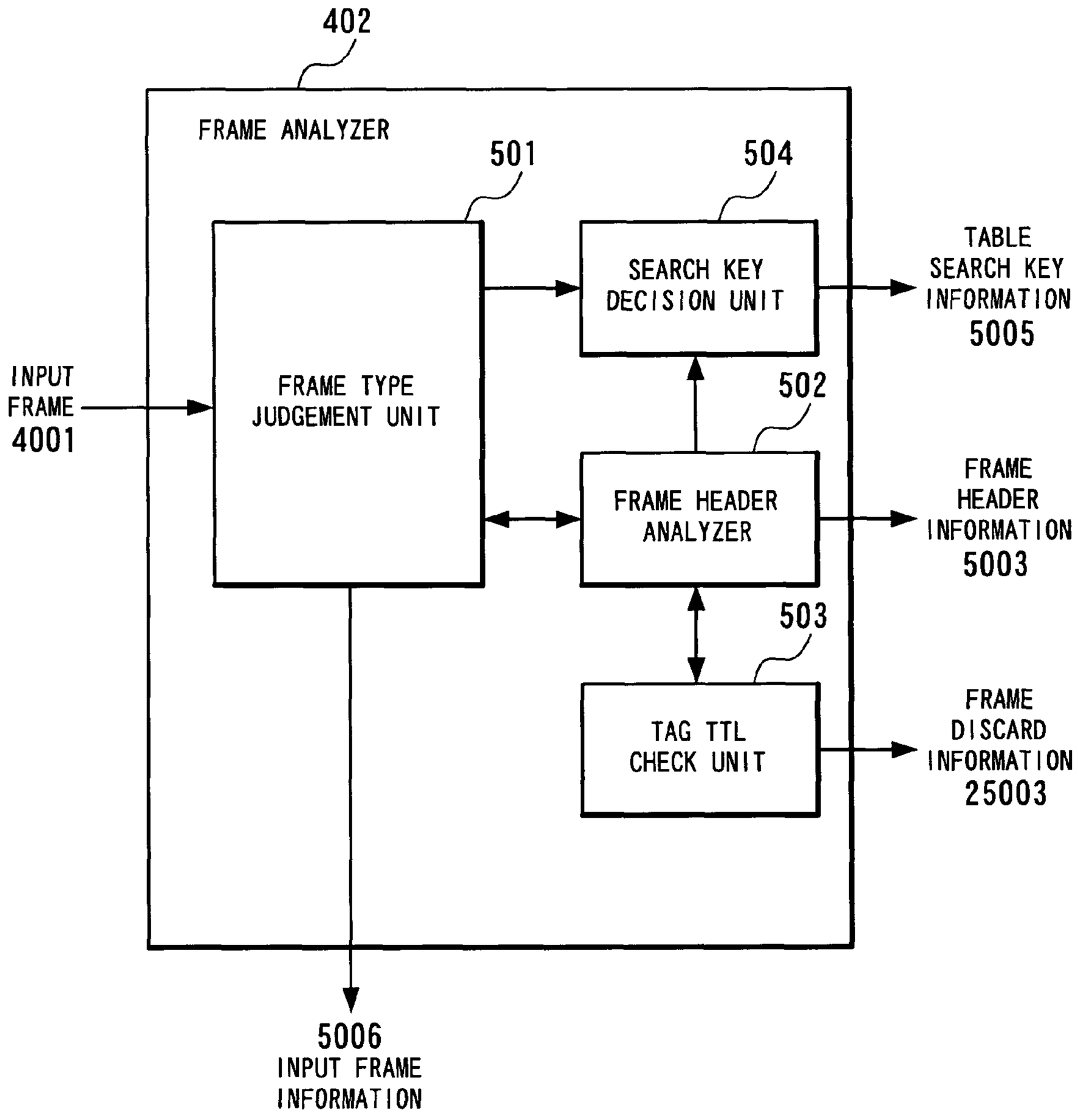

402
FRAME ANALYZER
501
504
INPUT FRAME 4001
FRAME TYPE JUDGEMENT UNIT
SEARCH KEY DECISION UNIT
TABLE SEARCH KEY INFORMATION 5005
502
FRAME HEADER ANALYZER
FRAME HEADER INFORMATION 5003
503
TAG TTL CHECK UNIT
FRAME DISCARD INFORMATION 25003
5006
INPUT FRAME INFORMATION

FIG. 4

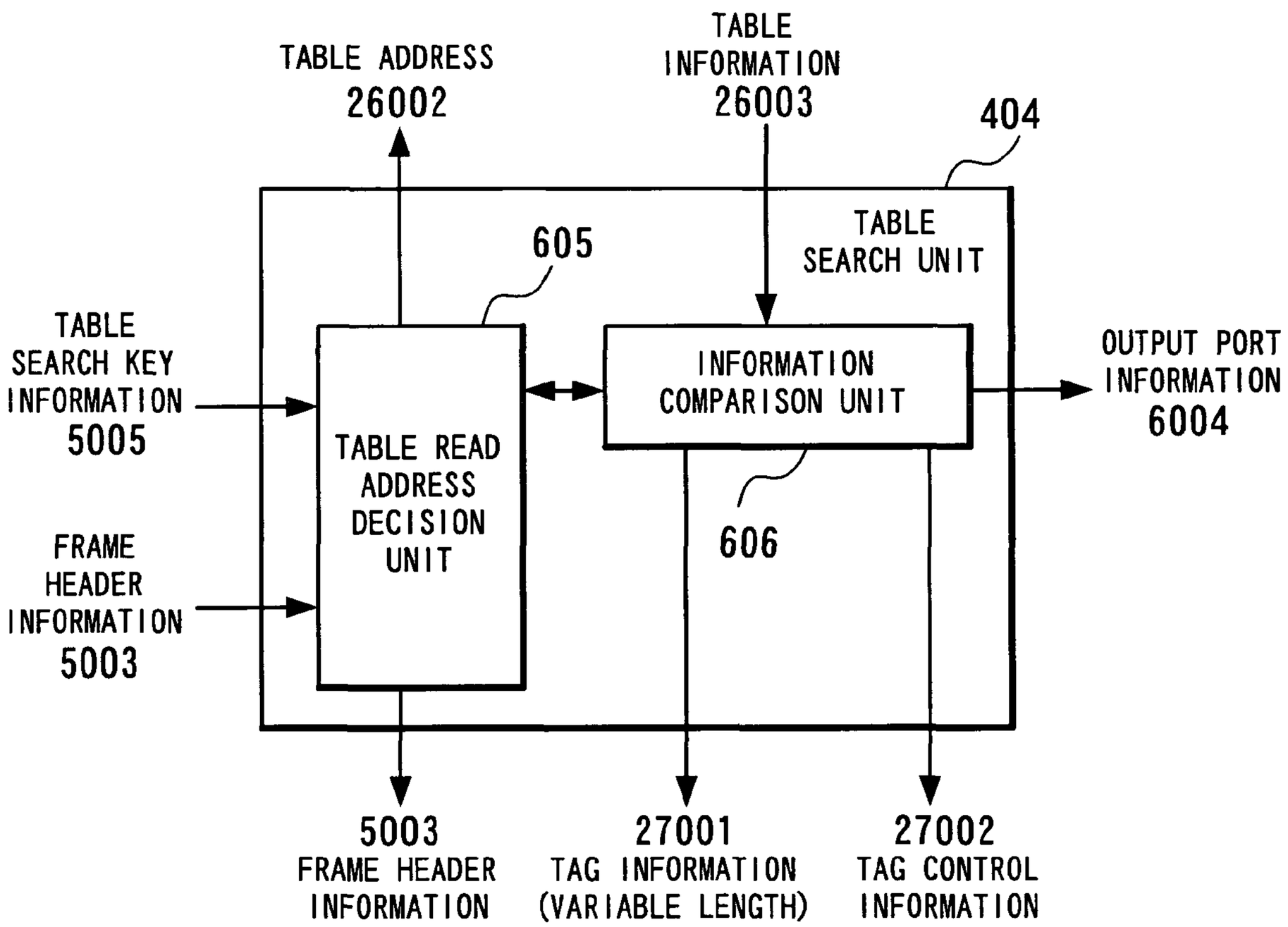


TABLE ADDRESS
26002
TABLE INFORMATION
26003
404
TABLE SEARCH UNIT
605
TABLE SEARCH KEY INFORMATION
5005
TABLE READ ADDRESS DECISION UNIT
INFORMATION COMPARISON UNIT
OUTPUT PORT INFORMATION
6004
606
FRAME HEADER INFORMATION
5003
5003
FRAME HEADER INFORMATION
27001
TAG INFORMATION (VARIABLE LENGTH)
27002
TAG CONTROL INFORMATION

FIG. 5

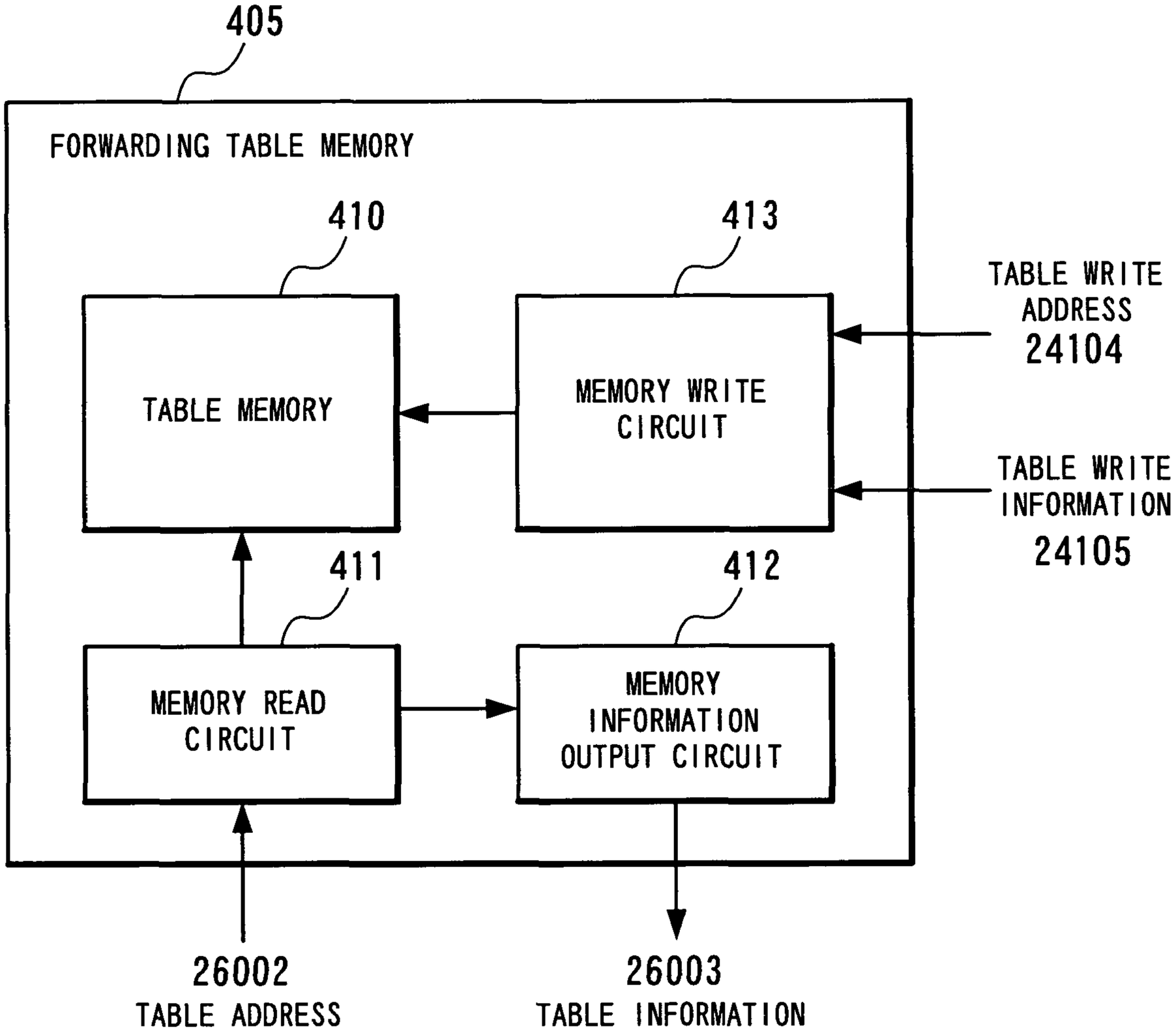

405
FORWARDING TABLE MEMORY
410
TABLE MEMORY
413
MEMORY WRITE CIRCUIT
TABLE WRITE ADDRESS
24104
TABLE WRITE INFORMATION
24105
411
MEMORY READ CIRCUIT
412
MEMORY INFORMATION OUTPUT CIRCUIT
26002
TABLE ADDRESS
26003
TABLE INFORMATION

FIG. 6

410

MAC SOURCE ADDRESS (48 BITS)	FIRST STEP TAG INFORMATION (32 BITS)	SECOND STEP TAG INFORMATION (32 BITS)	. . .	N STEP TAG INFORMATION (32 BITS)	NUMBER OF TAG CONTROL STEPS	TAG CONTROL INFORMATION	OUTPUT PORT INFORMATION
00-00-0c-01-02-03	OPERATION TAG TYPE	OPERATION INFORMATION	. . .	OPERATION INFORMATION	4	TAG INSERTION	1
00-00-0c-01-02-04	BUS PROVISIONING TAG TYPE	BUS PROVISIONING INFORMATION	. . .	BUS PROVISIONING INFORMATION	4	TAG REPLACEMENT	1
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
00-00-0c-01-02-05	ADDRESS INFORMATION TAG TYPE	ADDRESS INFORMATION	. . .	ADDRESS INFORMATION	3	TAG INSERTION	2
00-00-0c-01-02-05	FAILURE AVOIDANCE TAG TYPE	BYPASS INFORMATION	. . .	BYPASS INFORMATION	2	TAG INSERTION	2
00-00-0c-01-02-05	FAILURE NOTICE TAG TYPE	DEVICE FAILURE INFORMATION	. . .	DEVICE FAILURE INFORMATION	2	TAG INSERTION	2
00-00-0c-01-02-05	MAINTENANCE TAG TYPE	MAINTENANCE INFORMATION	. . .	MAINTENANCE INFORMATION	4	TAG REMOVE	0

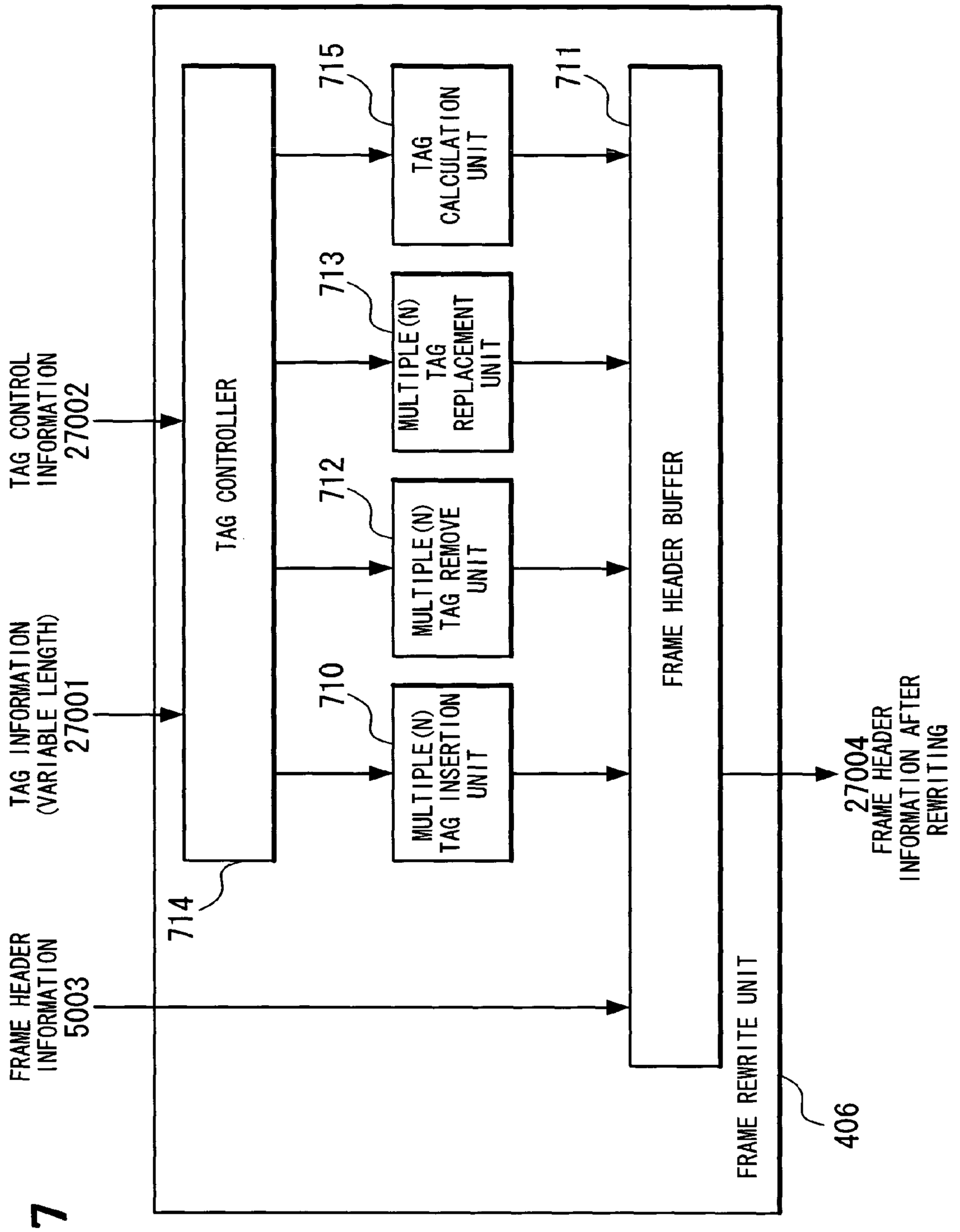

FRAME HEADER INFORMATION 5003
TAG INFORMATION (VARIABLE LENGTH) 27001
TAG CONTROL INFORMATION 27002
714
TAG CONTROLLER
710
MULTIPLE(N) TAG INSERTION UNIT
712
MULTIPLE(N) TAG REMOVE UNIT
713
MULTIPLE(N) TAG REPLACEMENT UNIT
715
TAG CALCULATION UNIT
711
FRAME HEADER BUFFER
FRAME REWRITE UNIT
406
27004 FRAME HEADER INFORMATION AFTER REWRITING

FIG. 7

FIG. 8

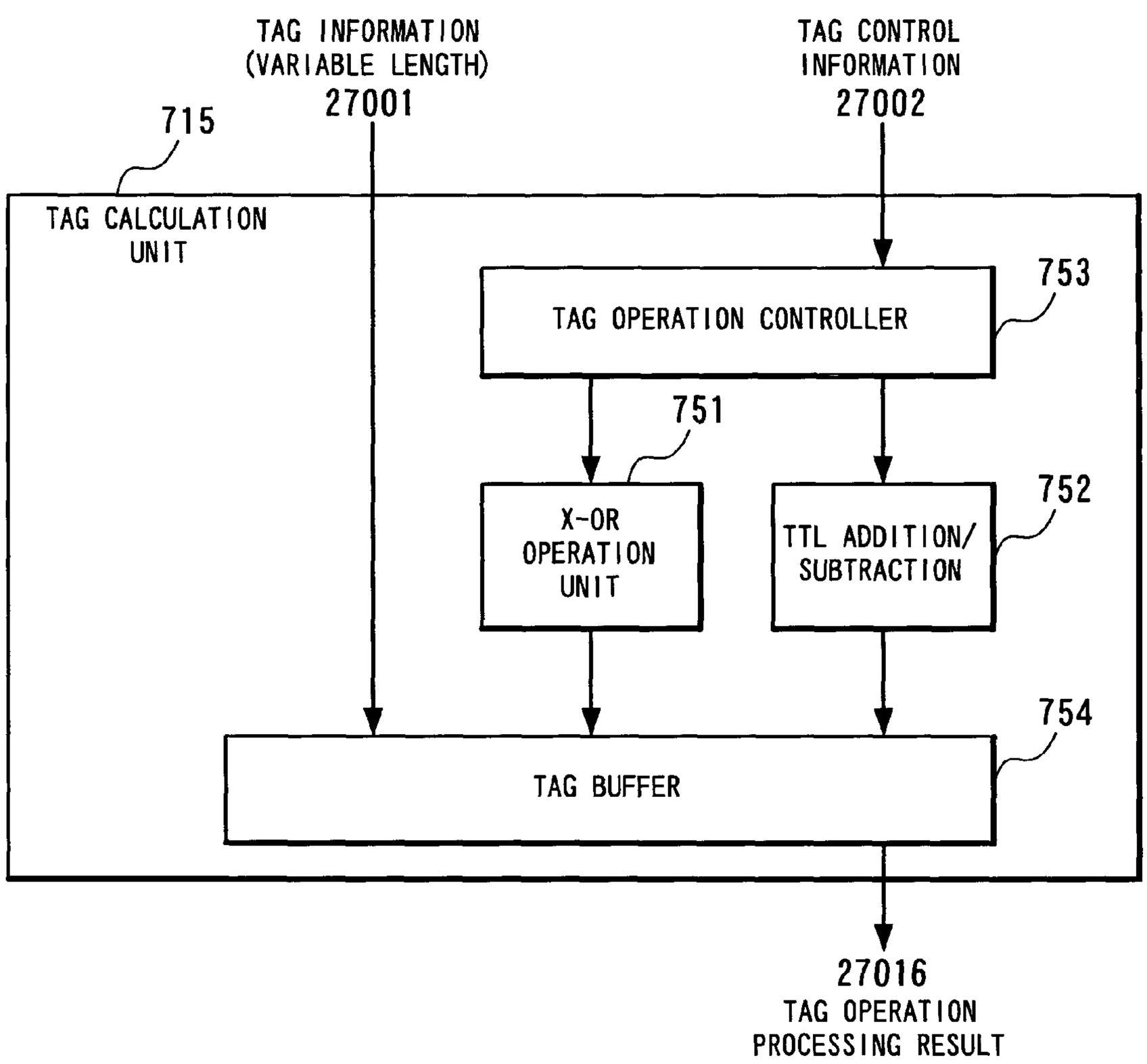

TAG INFORMATION
(VARIABLE LENGTH)
27001
TAG CONTROL
INFORMATION
27002
715
TAG CALCULATION
UNIT
TAG OPERATION CONTROLLER
753
751
X-OR
OPERATION
UNIT
TTL ADDITION/
SUBTRACTION
752
TAG BUFFER
754
27016
TAG OPERATION
PROCESSING RESULT

FIG. 9

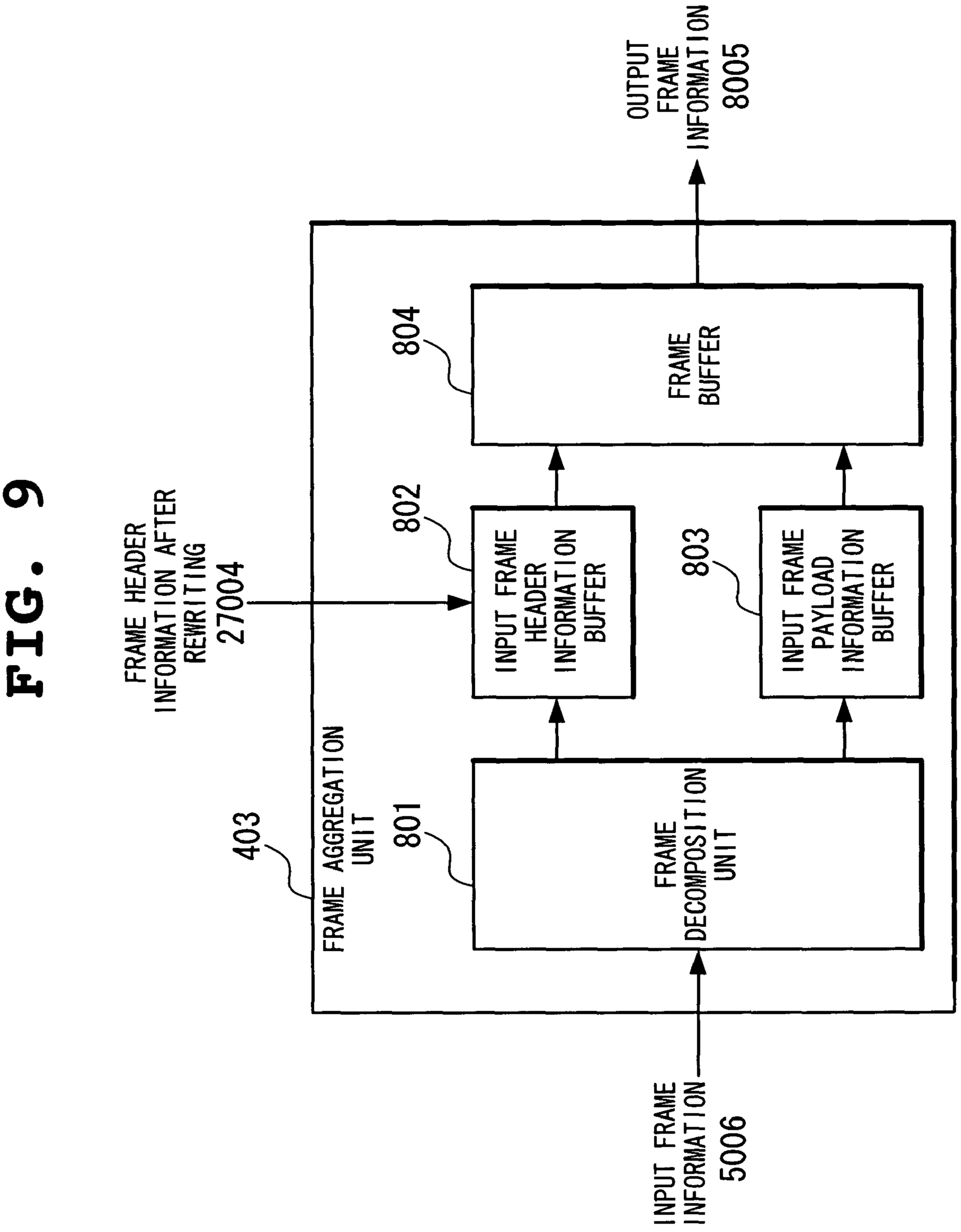

OUTPUT FRAME INFORMATION 8005
FRAME AGGREGATION UNIT
403
FRAME DECOMPOSITION UNIT
801
INPUT FRAME HEADER INFORMATION BUFFER
802
INPUT FRAME PAYLOAD INFORMATION BUFFER
803
FRAME BUFFER
804
FRAME HEADER INFORMATION AFTER REWRITING
27004
INPUT FRAME INFORMATION
5006

FIG. 10

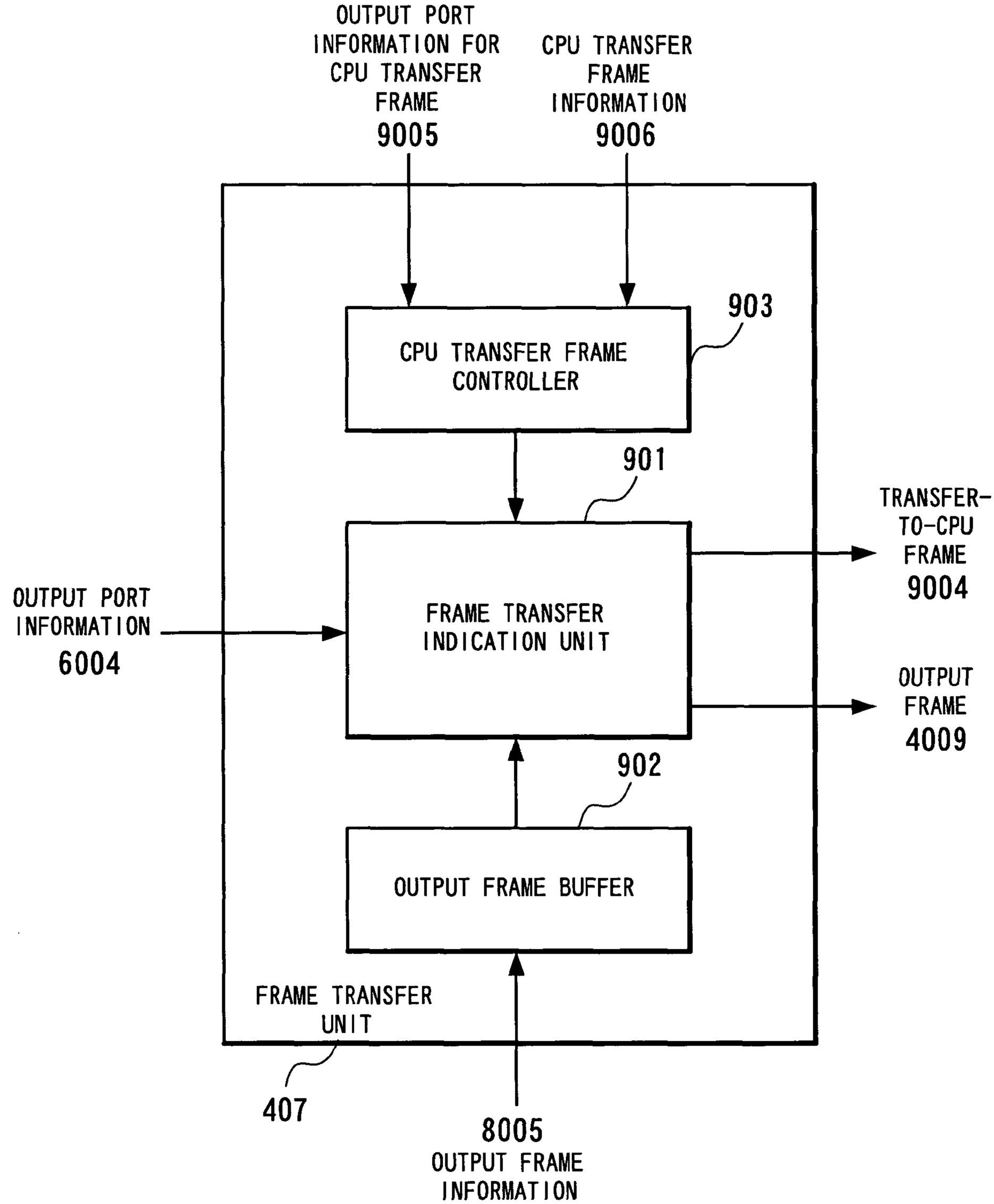

OUTPUT PORT INFORMATION FOR CPU TRANSFER FRAME
9005
CPU TRANSFER FRAME INFORMATION
9006
CPU TRANSFER FRAME CONTROLLER
903
901
FRAME TRANSFER INDICATION UNIT
TRANSFER-TO-CPU FRAME
9004
OUTPUT PORT INFORMATION
6004
OUTPUT FRAME
4009
902
OUTPUT FRAME BUFFER
FRAME TRANSFER UNIT
407
8005
OUTPUT FRAME INFORMATION

FIG. 11

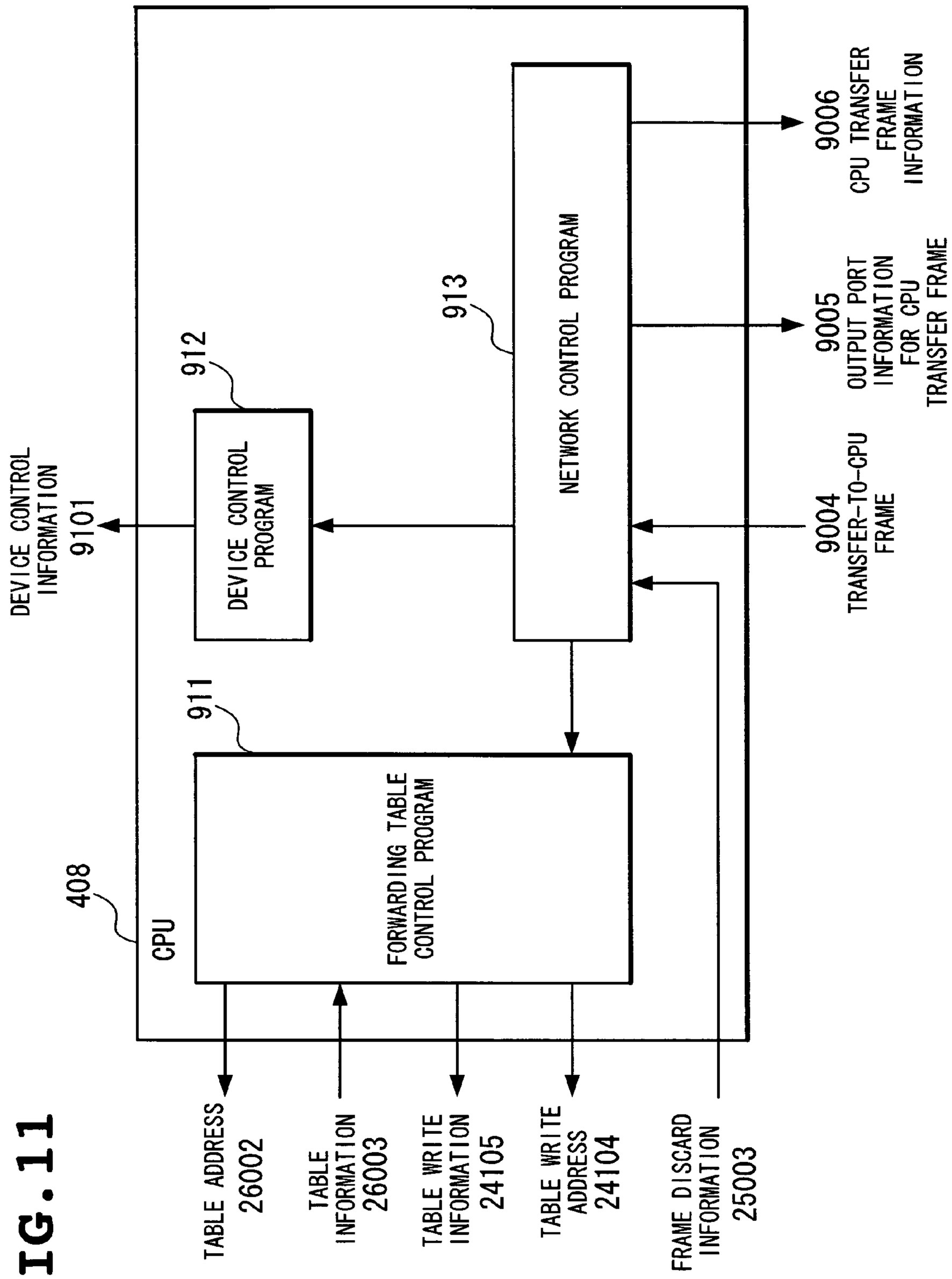

408
CPU
912
913
911
DEVICE CONTROL INFORMATION 9101
DEVICE CONTROL PROGRAM
NETWORK CONTROL PROGRAM
FORWARDING TABLE CONTROL PROGRAM
9004 TRANSFER-TO-CPU FRAME
9005 OUTPUT PORT INFORMATION FOR CPU TRANSFER FRAME
9006 CPU TRANSFER FRAME INFORMATION
TABLE ADDRESS 26002
TABLE INFORMATION 26003
TABLE WRITE INFORMATION 24105
TABLE WRITE ADDRESS 24104
FRAME DISCARD INFORMATION 25003

FIG.12

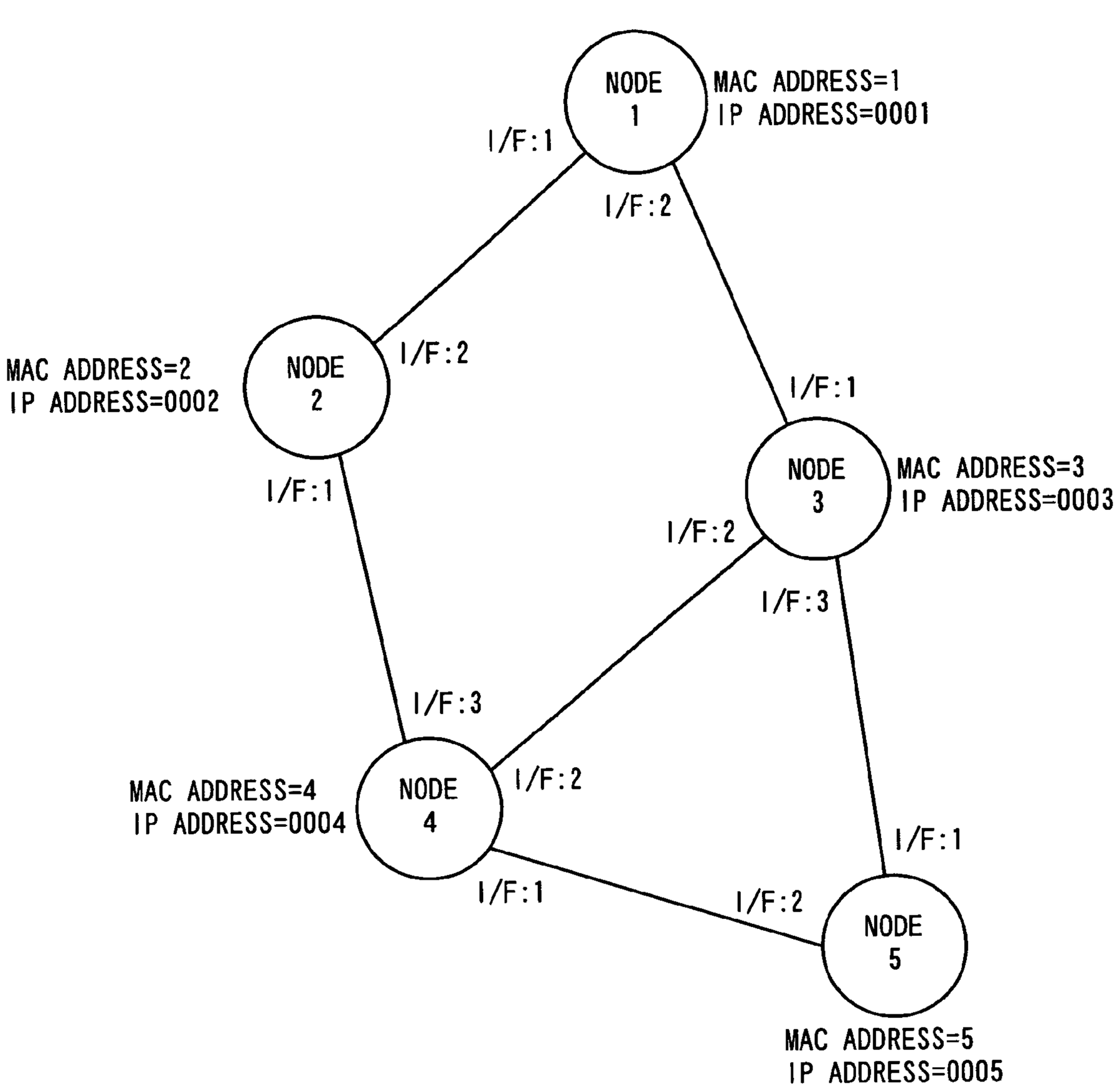

NODE 1
MAC ADDRESS=1
IP ADDRESS=0001
I/F:1
I/F:2
NODE 2
MAC ADDRESS=2
IP ADDRESS=0002
I/F:2
I/F:1
NODE 3
MAC ADDRESS=3
IP ADDRESS=0003
I/F:1
I/F:2
I/F:3
NODE 4
MAC ADDRESS=4
IP ADDRESS=0004
I/F:3
I/F:2
I/F:1
I/F:1
I/F:2
NODE 5
MAC ADDRESS=5
IP ADDRESS=0005

FIG.13

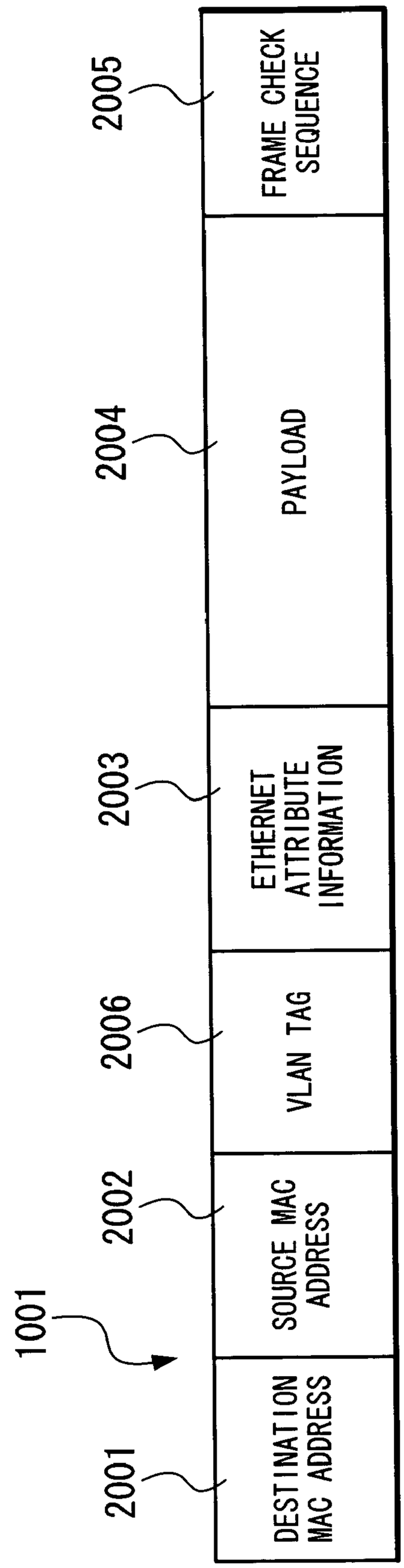

2005
FRAME CHECK SEQUENCE
2004
PAYLOAD
2003
ETHERNET ATTRIBUTE INFORMATION
2006
VLAN TAG
2002
SOURCE MAC ADDRESS
1001
2001
DESTINATION MAC ADDRESS

FIG. 14

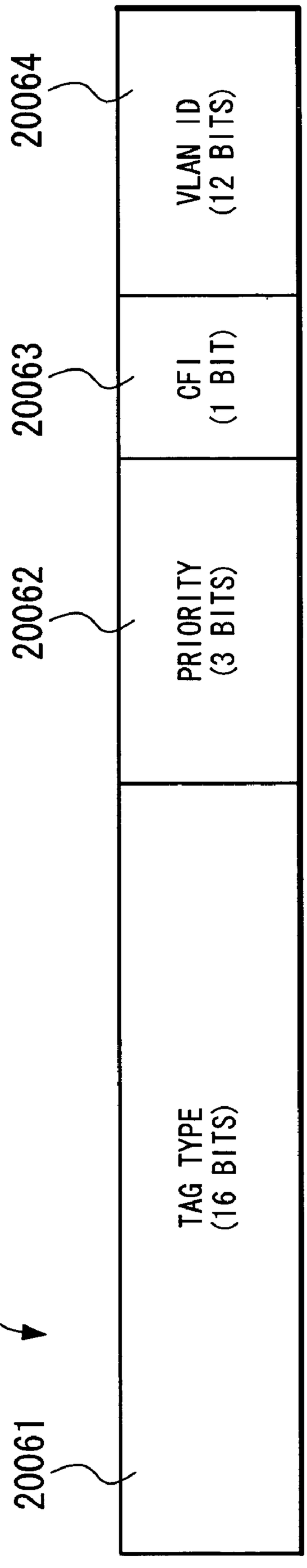

2006
20061
TAG TYPE
(16 BITS)
20062
PRIORITY
(3 BITS)
20063
CFI
(1 BIT)
20064
VLAN ID
(12 BITS)

FIG. 15

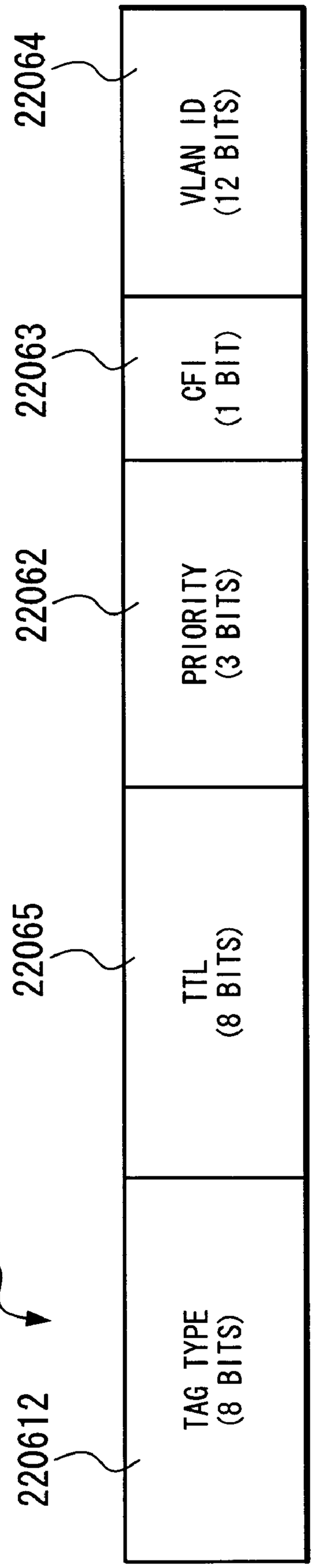

2206
22065
TTL
(8 BITS)
22062
PRIORITY
(3 BITS)
22063
CFI
(1 BIT)
22064
VLAN ID
(12 BITS)
220612
TAG TYPE
(8 BITS)

FIG. 16

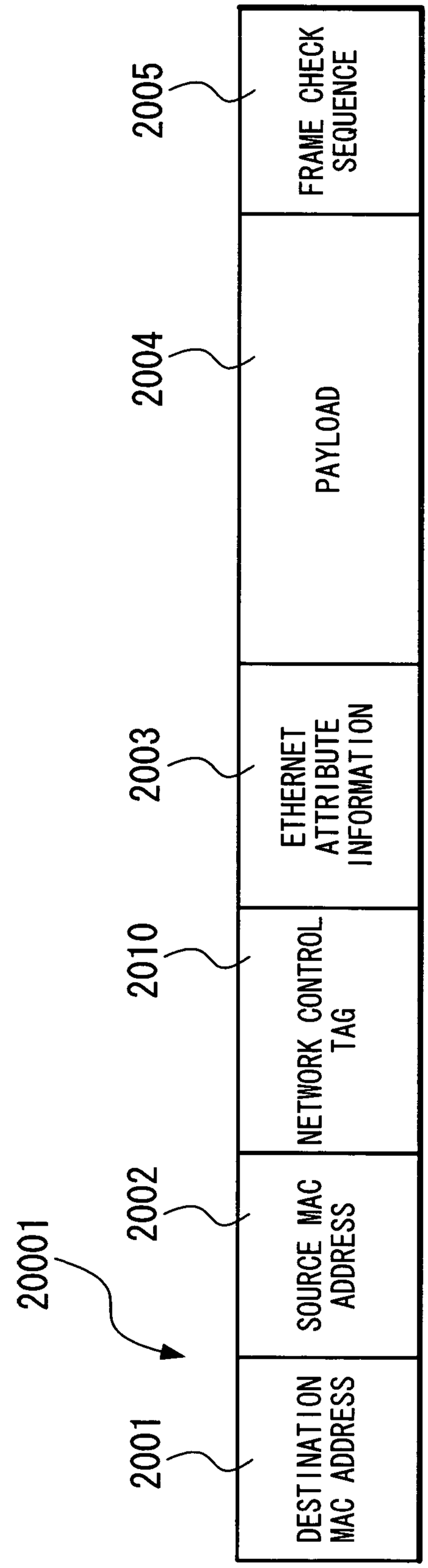

20001
2001
DESTINATION MAC ADDRESS
2002
SOURCE MAC ADDRESS
2010
NETWORK CONTROL TAG
2003
ETHERNET ATTRIBUTE INFORMATION
2004
PAYLOAD
2005
FRAME CHECK SEQUENCE

FIG. 17

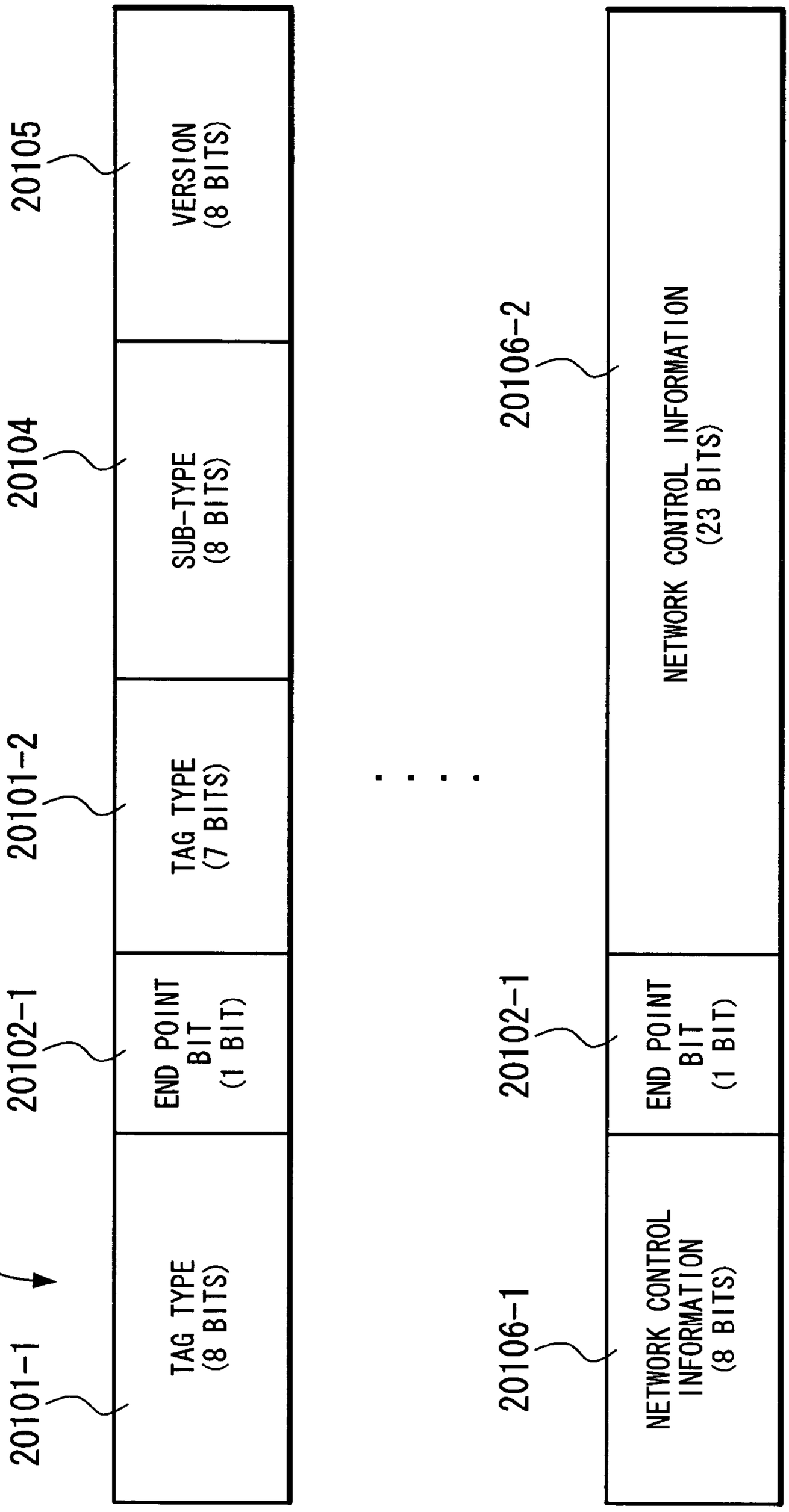
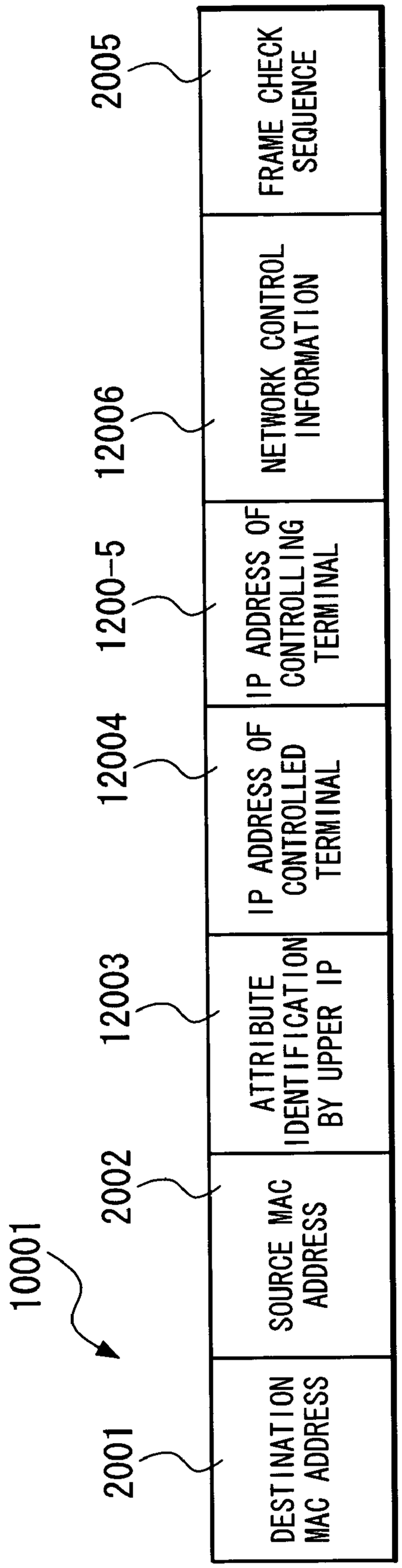

2010
20101-1
TAG TYPE (8 BITS)
20102-1
END POINT BIT (1 BIT)
20101-2
TAG TYPE (7 BITS)
20104
SUB-TYPE (8 BITS)
20105
VERSION (8 BITS)
20106-1
NETWORK CONTROL INFORMATION (8 BITS)
20102-1
END POINT BIT (1 BIT)
20106-2
NETWORK CONTROL INFORMATION (23 BITS)

FIG. 18 (PRIOR ART)



FRAME TRANSFER METHOD AND NODE IN ETHERNET

BACKGROUNDS OF THE INVENTION

1. Field of the Invention

The present invention relates to a node to relay the Ethernet frame and a frame transfer method.

2. Description of the Related Art

Conventionally, a node in Ethernet is controlled with a network control frame shown in FIG. **18** storing the network control information **12006** in the payload section and the address of the node to be controlled in the MAC address (Destination MAC address **2001** and the source MAC address **2002**) and the IP address (IP address of controlled terminal **12004**).

Therefore, while the user uses the entire network bandwidth for data transmission, the node cannot send the control frame. In addition, the control frame needs to have at least 64 bytes regardless of the control information amount for the node according to Ethernet standard specified by IEEE802.3.

IEEE802.1Q, that provides for the technology related to the VLAN, specifies that a VLAN tag shall be given to a frame during frame relay for network separation.

Therefore, the node that relays conventional Ethernet frames has a function to process at most one VLAN tag at a time in frame relay and the forwarding table to store the VLAN tag information given during such frame relay assures an information area for one VLAN tag only.

In addition, since the VLAN tag in the frame is the information for network separation, the node that relays the frame with VLAN tag does not have a function to change the contents of the VLAN tag. The information in the VLAN tag is used for frame transfer only.

Further, in transmission of the VLAN frame at the data link layer, the frame is relayed and the transfer port is determined by reference to the MAC address and the VLAN ID.

The conventional node control in Ethernet as described above has drawbacks as follows:

Firstly, the conventional node in Ethernet as specified in IEEE802.3 is controlled using the frame storing the control information in the payload section and the address of the node to be controlled in the MAC address and the IP address as shown in FIG. **18**. Thus, while the user uses the entire network bandwidth for data transmission, the node cannot send the control frame.

Secondly, the control frame needs to have at least 64 bytes regardless of the control information amount for the node according to Ethernet standard. If the control frame is frequently sent in the network, it may oppress the bandwidth of the user data.

Thirdly, when the VLAN tag is given for frame transfer, several VLAN tags cannot be provided because there is no information area in the forwarding table.

Fourthly, in case a loop network is formed in IEEE802.3 Ethernet, because a function to discard frames when a loop of packet transfer is generated in VLAN packet transfer at the data link layer has not been realized, the looped packets occupy the network or induce oppression of the packet memory in the system, which results in unstable status of the network.

SUMMARY OF THE INVENTION

A first object of the present invention is to propose a frame transfer method and a node in Ethernet that enable transmission of the network control information from the node even while the user is using the network.

A second object of the present invention is to propose a frame transfer method and a node in Ethernet that can minimize oppression of the network bandwidth caused by transmission of the network control information by enabling transmission of the minimum information regardless of the frame restriction.

A third object of the present invention is to propose a frame transfer method and a node in Ethernet that can send a large information amount including the network control information as tags by enabling provision of several tags in frame transfer.

A fourth object of the present invention is to enable discarding of frames in VLAN packet transfer at the data link layer and to thereby propose a frame transfer method and a node in Ethernet that prevent the network to be unstable by avoiding occupation of the network by looped packets and oppression of the packet memory in the system.

According to the first aspect of the invention, a node to relay the Ethernet frame comprising element which inserts two or more VLAN tags into the frame and removes the inserted VLAN tag in the relay process of the frame.

In the preferred construction, a node further comprises element which replaces two or more VLAN tags of the frame at a time.

In another preferred construction, a node further comprises element which administrates the two or more VLAN tags using the forwarding table memory for change of frame contents during frame relay.

In another preferred construction, a node further comprises element which searches the forwarding table memory using the information from two or more VLAN tags in the frame during frame relay.

In another preferred construction, a node further comprises element which searches the forwarding table memory in the relay process of the frame with combining the information from two or more VLAN tags in the frame and the input port, the destination MAC address, the source MAC address and the TYPE field information.

In another preferred construction, a node comprises element which provides a TTL area to show the survival time of the frame in the VLAN tag inserted to the frame and checks whether the survival time has elapsed or not by the value in the TTL area and discards the frame after elapse of the survival time without relaying it in the relay process of the frame.

In another preferred construction, a node further comprises element which decrements the value in the TTL area by one every time the frame is relayed.

In another preferred construction, node control information is stored to the VLAN tag.

In another preferred construction, a node further comprises element which changes the self-node status administration corresponding to the contents of the VLAN tag.

In another preferred construction, the node status is stored to the area of the VLAN tag in the relayed frame corresponding to the self-node status.

According to another aspect of the invention, a frame transfer method of the node to relay the Ethernet frame comprising a step of inserting two or more VLAN tags to the frame at a time or removing the inserted VLAN tags in the relay process of the frame.

In the preferred construction, a forwarding table memory for frame contents change during frame relay is used for administration of the two or more VLAN tags.

In another preferred construction, a forwarding table memory is searched during frame relay using the information from two or more VLAN tags in the frame.

In another preferred construction, a forwarding table memory is searched in the relay process of the frame-with combining the information from two or more VLAN tags in the frame and the input port, the destination MAC address, the source MAC address and the TYPE field information.

In another preferred construction, a TTL area to show the survival time of the frame is provided in the VLAN tag that is inserted to the frame and whether the survival time has been elapsed or not is checked by the value in the TTL area and the frame after elapse of the survival time is discarded without being relayed in the relay process of the frame.

In another preferred construction, the value in the TTL area is decremented by one every time the frame is relayed.

In another preferred construction, node control information is stored to the VLAN tag.

In another preferred construction, a frame transfer method further comprises changing the self-node status administration corresponding to the contents of the VLAN tag.

In another preferred construction, node status is stored to the VLAN tag area in the relayed frame corresponding to the self-node status.

Other objects, features and advantages of the present invention will become clear from the detailed description given herebelow.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood more fully from the detailed description given herebelow and from the accompanying drawings of the preferred embodiment of the invention, which, however, should not be taken to be limitative to the invention, but are for explanation and understanding only.

In the drawings:

FIG. **1** is a block diagram showing the configuration of a VLAN switching hub according to an embodiment of the present invention;

FIG. **2** is a block diagram showing the configuration of a packet forwarding unit according to an embodiment of the present invention;

FIG. **3** is a block diagram showing the configuration of a frame analyzer in the packet forwarding unit;

FIG. **4** is a block diagram showing the configuration-of a table search unit in the packet forwarding unit;

FIG. **5** is a block diagram showing the configuration of a forwarding table memory in the packet forwarding unit;

FIG. **6** is a configuration diagram of a table memory in the forwarding table memory;

FIG. **7** is a block diagram showing the configuration of a frame rewrite unit in the packet forwarding unit;

FIG. **8** is a block diagram showing the configuration of a tag calculation unit in the frame rewrite unit;

FIG. **9** is a block diagram showing the configuration of a frame aggregation unit in the packet forwarding unit;

FIG. **10** is a block diagram showing the configuration of a frame transfer unit in the packet forwarding unit;

FIG. **11** is a configuration diagram of a CPU in the VLAN switching hub;

FIG. **12** is a diagram showing an example of network configuration;

FIG. **13** is a configuration diagram of an Ethernet frame with a standard VLAN tag;

FIG. **14** is a configuration diagram of a standard VLAN tag;

FIG. **15** is a configuration diagram of a tag according to the present invention;

FIG. **16** is a configuration diagram of a network control frame according to the present invention;

FIG. **17** is a configuration diagram of a network control tag according to the present invention; and

FIG. **18** is a configuration diagram of a standard network control frame.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiment of the present invention will be discussed hereinafter in detail with reference to the accompanying drawings. In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be obvious, however, to those skilled in the art that the present invention may be practiced without these specific details. In other instance, well-known structures are not shown in detail in order to unnecessary obscure the present invention.

Referring to the attached figures, embodiments of the present invention will be described in details below.

FIG. **1** is a configuration diagram of a VLAN switching hub in the node to relay the Ethernet frame as an application of the present invention. The VLAN switching hub comprises a packet forwarding unit **201**, a system device **401**, a console I/O **95** and a packet switching unit **91** and is provided with MAC layer interfaces **111** to **114** and PHY layer interfaces **311** to **314**.

FIG. **2** shows the configuration of the packet forwarding unit **201**. The packet forwarding unit **201** comprises a frame analyzer **402**, a forwarding table memory **405**, a table search unit **404** and a frame rewrite unit **406** having the characteristic function of the present invention in addition to a frame aggregation unit **403** and a frame transfer unit **407**.

The present invention further uses a VLAN tag frame utilizing a tag format with TTL bit **2206** as shown in FIG. **15** and an IEEE802.3 network control frame **20001** as shown in FIG. **16** utilizing a network control tag format **2010** as shown in FIG. **17**.

As an embodiment of the present invention, the frame transfer taking advantage of the IEEE802.3 network control frame **20001** as shown in FIG. **16** using a tag TTL check unit **503** in the frame analyzer **402** of the present invention as shown in FIG. **3**, a tag calculation unit **715**, an Multiple(N) tag insertion unit **710**, an Multiple(N) tag remove unit **712** and an Multiple(N) tag replacement unit **713** in the frame rewrite unit **406** as shown in FIG. **7**, a table memory **410** as shown in FIG. **6**, the tag format **2206** as shown in FIG. **15** and the network control tag format **2010** as shown in FIG. **17** is described below.

The tag format **2206** as shown in FIG. **15** has a tag format configuration that stores TTL (frame survival time) information to the lower 8-bit area in the 16-bit area of the tag type **20061** according to the VLAN tag format **2006** as shown in FIG. **14**.

A TTL area **22065** has a value from 0 at the minimum to 255 at the maximum. The value "255" is stored at the packet transfer start position, but it is decremented by one for every transfer by a node. The value "0" means that the frame can be discarded.

The network control frame **20001** as shown in FIG. **16** stores the network control tag **2010** in the frame transferred by the user in order for network control.

The network control tag **2010** is constituted according to the format in FIG. **17**. Tag types **20101-1** and **20101-2** store the type of the network control tag as 15-bit information. An end point bit **20102-1** shows the end point of several tags

stacked. A subtype **20104** is used to show more detailed type of the tag type **20101**. A version **20105** shows the version information for the specification of the network control frame **20001**.

These 32 bits in total are treated as an initial tag of the network control tag and followed by several tags. One tag has the information for network control and administration of 31 bits in total as network control information **20106-1** and **20106-2** and an end point bit **20102-2** showing the end point of the final tag is added.

The VLAN switching hub **20** as shown in FIG. **1** is provided with at most four ports of interfaces (IF) that enable transfer of frames including Ethernet frame with VLAN tag **1001** as shown in FIG. **13** and the tag **2206** having the format shown in FIG. **15**.

The VLAN switching hub **20** is installed at the nodes **1** to **5** of the network as shown in FIG. **12** and serves for frame transfer processing.

Frame transfer from I/F:**1** to I/F:**2** at node **4** as shown in FIG. **12** is described below.

A frame input from I/F:**1** of the VLAN switching hub **20** is, via PHY**311** and MAC**111**, input as an input frame **4001** to the packet forwarding unit **201** as shown in FIG. **2**.

In the packet forwarding unit **201**, the input frame **4001** is sent to the frame type judgement unit **501** of the frame analyzer **402** in FIG. **3**.

The frame type judgement unit **501** identifies the type of the input frame **4001** and sends the frame type information to the search key decision unit **504** and the header information of the input frame **4001** to the frame header analyzer **502**.

The frame header analyzer **502** analyzes the header information and extracts the destination MAC address information **2001**, source MAC address information **2002**, VLAN tag information **2006** and Ethernet attribute information **2003** as shown in FIG. **13** from the header information.

Among the extracted header information, the VLAN tag information **2006** is sent to the tag TTL check unit **503**, which is a characteristic component of the present invention, to check whether the value of the TTL area **22065** in FIG. **15** is "0" or not.

If the value of the TTL area **22065** is "0" as a result of the check, frame discard information **25003** is output and the instruction to discard the frame is sent to the frame header analyzer **502**.

If the value of the TTL area **22065** is not "0", the frame discard information **25003** is not output and the frame discard instruction is not sent.

When the frame header analyzer **502** receives the instruction to discard the frame, it instructs the frame type judgement unit **501** not to output input frame information **5006** and executes the frame discarding for the input frame **4001**.

When the frame discard instruction is not given, the frame header analyzer **502** outputs the frame header information **5003** and sends the header information to the search key decision unit **504**.

The search key decision unit **504** decides the port used for frame transfer and the table search key to find the processing method for the frame from the frame type and the header information and sends table search key information **5005** to the table search unit **404** in FIG. **4**.

The frame type judgement unit **501** outputs the input frame **4001** as the input frame information **5006** in case any frame discard instruction is not given to the frame header analyzer **502**.

In the table search unit **404** of FIG. **4**, the table search key information **5005** and frame header information **5003** are input to a table read address decision unit **605**.

The table read address decision unit **605** estimates and calculates the address where the same information as the table search key information **5005** is stored from its information, decides the table reference address and sends a table address **26002** to the forwarding table memory **405** of FIG. **5**.

The forwarding table memory **405**, using the information at the table address **26002**, refers to the contents of the table memory **410** with a memory read circuit **411** and sends the referred information as table information **26003** to the table search unit **404** with a memory information output circuit **412**.

According to the present invention, the table memory **410** comprises a memory table as shown in FIG. **6**. It stores the tag information at the first step and several pieces of tag information from the second step as well as the number of control steps required for control of several pieces of tag information and the control information. Thus, several pieces of tag information are sent to the table search unit **404** at a time as the table information **26003**.

The table memory **410** as shown in FIG. **6** is described below. The table memory **410** administrates several pieces of tag information as described above. In this table, frames for insertion of the network control tag **2010** as shown in FIG. **16** are administrated and the information required for network control is sent and received.

The contents of the first entry in the table of FIG. **6** represent that, because the number of tag control steps is "4" for a frame with the source MAC address "00-00-0c-01-02-03", a four-step tag storing the operation information for network control is inserted.

Further, the contents of the final entry in the table show that the source MAC address is "00-00-0c-01-02-05" and the frame storing the maintenance information sends the frame as a transfer-to-CPU frame **9004** shown in FIG. **10** to a CPU **408** and receives the network control information because the output port information is "0".

For table search key information **5005** used in the two cases above, the former is the MAC source address: 00-00-0c-01-02-03 and the latter is the source MAC address 00-00-0c-01-02-05 and the tag information (Maintenance information). Thus, the network control tag **2010** is stored in the transfer frame so that the information required for network control is exchanged.

The table information **26003** sent from the forwarding table memory **405** to the table search unit **404** is input to an information comparison unit **606** and compared with the table search key information **5005** to see if they are the same.

If they are the same as a result of comparison, output port information of the frame is output to output port information **6004** and the information comparison unit **606** outputs tag information **27001** and tag control information **27002** and the table read address decision unit **605** sends the frame header information **5003** both to the frame rewrite unit **406**.

If they are not the same, decision of the table read address is requested again to the table read address decision unit **605** and the table information **26003** is obtained from the forwarding table memory **405** until the information equal to the table search key information **5005** is obtained.

If the same information cannot be obtained even after checking the whole area of the forwarding table memory **405**, information to the CPU is sent to the output port information **6004** and the frame is transferred to the CPU **408** as the transfer-to-CPU frame **9004** as shown in FIG. **10**.

In the frame rewrite unit **406** as shown in FIG. **7**, a frame header buffer **711** stores information of the frame header

information **5003** and the variable length tag information **27001** and the tag control information **27002** are input to a tag controller **714**.

The tag controller **714** sends the tag information **27001** and the control instruction to one of the following units: the Multiple(N) tag insertion unit **710**, the Multiple(N) tag remove unit **712**, the Multiple(N) tag replacement unit **713** and the tag calculation unit **715** corresponding to the contents of the tag control information **27002**.

Here, the Multiple(N) tag insertion unit **710**, the Multiple (N) tag remove unit **712**, the Multiple(N) tag replacement unit **713** and the tag calculation unit **715** in FIG. **7** are described below.

The Multiple(N) tag insertion unit **710** takes out the information from the tag information **27001** for the number of steps instructed by the tag controller **714** and inserts several tags to the header information stored in the frame header buffer **711**.

Similarly, the Multiple(N) tag remove unit **712** and the Multiple(N) tag replacement unit **713** take out the information from the tag information **27001** for the number of steps instructed by the tag controller **714** and removes and replaces several tags of the header information stored in the frame header buffer **711**.

As shown in FIG. **8**, the tag control information **27002** is sent to a tag operation controller **753** and the tag information **27001** is sent to a tag buffer **754** in the tag calculation unit **715**.

The tag operation controller **753** sends a control instruction to an X-OR operation unit **751** and a TTL addition/subtraction unit **752** corresponding to the contents of the tag control information **27002**.

When the control instruction is sent, the X-OR operation unit **751** executes X-OR operation and the TTL addition/subtraction unit **752** executes addition or subtraction for a part of the tag buffer **754**. The operation result is sent as the tag operation processing result **27016** to the frame header buffer in FIG. **7**.

The TTL addition/subtraction unit **752** decrements the contents by one every time the frame transfer is executed for the TTL area **22065** shown in FIG. **15**.

Thus, even when a route control that circulates in the network for a long time is executed, the frame is surely discarded after transfer for 255 times in the VLAN switching hub **20** according to the functions of the TTL addition/subtraction unit **752** and the above tag TTL check unit **503** as shown in FIG. **3**.

At the Multiple(N) tag insertion unit **710**, the Multiple(N) tag remove unit **712**, the Multiple(N) tag replacement unit **713** and the tag calculation unit **715** in FIG. **7**, the changed frame header buffer **711** is, after processing completion, rewritten and sent as frame header information **27004** to the frame aggregation unit **403** as shown in FIG. **9**.

At the frame aggregation unit **403** in FIG. **9**, input frame information **5006** is input from the frame analyzer **402** in FIG. **3** to a frame decomposition unit **801**.

At the frame decomposition unit **801**, the input frame information **5006** is decomposed to the header information and the payload information and the respective information is output to an input frame header information buffer **802** and an input frame payload information buffer **803**. If the frame header information **27004** is sent after frame rewriting, however, the input frame header information buffer **802** replaces the header information with the frame header information **27004** after frame rewriting.

After that, the input frame header information buffer **802** and the input frame payload information buffer **803** output the data to a frame buffer **804**. Thus, the header and the payload section are synthesized and output frame information **8005** is sent to the frame transfer unit **407** in FIG. **10**.

The frame transfer unit **407** in FIG. **10** stores the output frame information **8005** sent from the frame aggregation unit **403** to an output frame buffer **902**.

After that, a frame transfer indication unit **901** takes out the frame from the output frame buffer **902** and outputs the output frame **4009** to the port obtained from the output port information **6004** sent from the table search unit **404** in FIG. **4**

In this embodiment, the output port information stores the information of I/F:**2** and the frame is output from the I/F:**2** for the output frame **4009**. If the output port information **6004** is addressed to the CPU, the frame is output to the transfer-to-CPU frame **9004**.

In addition, the frame transfer indication unit **901** also processes the frame sending from the CPU **408**. For the frame sending from the CPU **408**, a network control program **913** of the CPU **408** as shown in FIG. **11** creates a frame and sends output port information **9005** for CPU transfer frame and CPU transfer frame information **9006** to a CPU transfer frame controller **903** in FIG. **10**.

After that, the CPU transfer frame controller **903** sends the frame information and the output port information and instructs the frame transfer indication unit **901** to send the frame.

The CPU **408** as shown in FIG. **11** is described below. In the CPU **408**, the network control program **913** for network control is operating and a forwarding table control program **911** that processes the frame transmission from the CPU as described above and operates the information from the forwarding table memory **405** and the table memory **410** as shown in FIGS. **5** and **6** described above is operating.

The forwarding table control program **911** outputs, according to the instruction from the network control program **913**, the information required for network control including the table write information **24015** and the table write address **24014** to the table memory **410** and thus controls sending and receiving of the information required for network control. In addition, a device control program **912** also runs on the CPU **408**. The device control program **912** outputs device control information **9101**, which is the information for device control, according to the network control program **913**.

Though the present invention has been described with showing preferred embodiments and examples so far, it is not limited to the above embodiments and the examples. It can be embodied with various changes without departing from the technological spirit of the invention.

As described above, excellent effects as shown below can be obtained by the present invention.

By realizing the function to insert the network control tag storing the network control information into the user frame, transmission of the network control information becomes available even while the user is using the network.

By storing the network control frame in tags, the network control information can be sent in the minimum size without being restricted by the minimum frame size of 64 bytes according to Ethernet standard and thereby suppression of the network bandwidth can be minimized.

With a circuit to process several tags and a table administration method to administrate several tags, it becomes possible to give several tags in frame transfer, which enables sending of a large amount of information such as network control information as tags.

With a TTL field provided in the tag to be processed at the date link layer, it becomes possible, through subtraction and checking by a TTL check circuit and a tag operation circuit, to discard the frame during VLAN packet transfer at the data

link layer even when a looped network is formed. Thus, occupation of the network by looped packets or oppression of the packet memory in the system is prevented, which results in prevention of unstable network.

Although the invention has been illustrated and described with respect to exemplary embodiment thereof, it should be understood by those skilled in the art that the foregoing and various other changes, omissions and additions may be made therein and thereto, without departing from the spirit and scope of the present invention. Therefore, the present invention should not be understood as limited to the specific embodiment set out above but to include all possible embodiments which can be embodies within a scope encompassed and equivalents thereof with respect to the feature set out in the appended claims.

The invention claimed is:

1. A node in an Ethernet network to relay a modified Ethernet frame, comprising:

an element which inserts two or more VLAN tags into said frame and removes an other VLAN tag in a relay process of said frame,

wherein said frame comprises an Ethernet frame, as modified such that network control information is selectively stored to said VLAN tags and said network control information is not restricted to a 64-byte minimum frame size restriction of network control information, as defined by a standard of said Ethernet.

2. A node as set forth in claim **1**, further comprising:

an element which replaces two or more VLAN tags of said frame at a time.

3. A node as set forth in claim **1**, further comprising:

an element which administrates said two or more VLAN tags using a forwarding table memory for a change of frame contents during a frame relay.

4. A node as set forth in claim **1**, further comprising:

an element which searches a forwarding table memory using an information from two or more VLAN tags in said frame during a frame relay.

5. A node as set forth in claim **1**, further comprising:

an element which searches a forwarding table memory in a relay process of said frame with a combination of an information from two or more VLAN tags in said frame and an input port, a destination MAC address, a source MAC address and a TYPE field information.

6. A node as set forth in claim **1**, further comprising an element which:

provides a TTL area to show a survival time of a frame in said VLAN tag inserted to said frame;

checks whether said survival time has elapsed or not by a value in said TTL area; and

discards said frame after elapse of said survival time without relaying said frame in a relay process of said frame.

7. A node as set forth in claim **6**, further comprising:

an element which decrements the value in said TTL area by one every time said frame is relayed.

8. The node of claim **1**, wherein said network control information comprises 32-bit network control tags.

9. A node as set forth in claim **1**, further comprising:

an element which changes a self-node status administration corresponding to a content of said VLAN tag.

10. A node as set forth in claim **1**, wherein

a node status is stored to an area of said VLAN tag in the relayed frame corresponding to a self-node status.

11. A frame transfer method of a node in an Ethernet network to relay a modified Ethernet frame, said method comprising:

receiving said frame in said node, said frame comprising an Ethernet frame as modified such that network control information can selectively be stored to a VLAN tag, said network control information not being restricted to a 64-byte minimum frame size restriction of network control information, as defined by a standard of said Ethernet;

inserting two or more VLAN tags into said frame and removing at least one other VLAN tag from said frame in a relay process of said frame; and

forwarding said frame.

12. A frame transfer method as set forth in claim **11**, wherein

a forwarding table memory for frame contents change during a frame relay is used for administration of said two or more VLAN tags.

13. A frame transfer method as set forth in claim **11**, wherein

a forwarding table memory is searched during a frame relay using an information from two or more VLAN tags in said frame.

14. A frame transfer method as set forth in claim **11**, wherein

a forwarding table memory is searched in a relay process of said frame with a combination of an information from two or more VLAN tags in said frame and an input port, a destination MAC address, a source MAC address and a TYPE field information.

15. A frame transfer method as set forth in claim **11**, wherein:

a TTL area to show a survival time of the frame is provided in said VLAN tag that is inserted to said frame;

whether said survival time has been elapsed or not is checked by a value in said TTL area; and

said frame after elapse of said survival time is discarded without being relayed in the relay process of said frame.

16. A frame transfer method as set forth in claim **15**, wherein the value in said TTL area is decremented by one every time said frame is relayed.

17. A frame transfer method as set forth in claim **11**, wherein

a node status is stored to said VLAN tag area in the relayed frame corresponding to a self-node status.

18. A frame transfer method as set forth in claim **11**, further comprising:

changing a self-node status administration corresponding to contents of said VLAN tag.

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